

What is claimed is:

1. An amplifier comprising:
a first magnetic region having a first magnetization;
a control region forming a first interface with the first magnetic region;
a second magnetic region forming a second interface with the control region, the second magnetic region having a second magnetization that is substantially perpendicular to the first magnetization; and
a wire positioned relative to the control region so that a current through the wire creates in the control region a magnetic field that rotates spins of the electrons injected through the control region between the first magnetic region and the second magnetic region.
2. The amplifier of claim 1, further comprising:
a first terminal connected to the first magnetic region;
a second terminal connected to the second magnetic region; and
a third terminal and a fourth terminal connected to ends of the wire, wherein a signal applied to the third and fourth terminals controls a current between the first and second terminals.
3. The amplifier of claim 1, wherein the control region is such that an electron spin relaxation time of the control region is longer than a transit time of the electrons traversing the control region.
4. The amplifier of claim 1, wherein the control region comprises a semiconductor material.
5. The amplifier of claim 4, wherein the semiconductor material is selected from a group consisting of Si, Ge, GaAs, GaInAs, Ge, ZnSe, ZnCdSe, and alloys and combinations of these materials.
6. The amplifier of claim 4, wherein the semiconductor material contains an n-type doping.

7. The amplifier of claim 1, wherein the first magnetic region comprises a ferromagnetic material.
8. The amplifier of claim 1, wherein the wire has a cross-sectional dimension less than 100 nm.
9. The amplifier of claim 1, wherein the control region has a thickness less than 100 nm.
10. The amplifier of claim 1, further comprising a substrate wherein:
the wire comprises a conductive region on the substrate;
the first magnetic region overlies the conductive region;
the control region overlies the first magnetic region; and
the second magnetic region overlies the control region.
11. The amplifier of claim 10, further comprising an insulating layer between the conductive region and the first magnetic region.
12. The amplifier of claim 11, wherein the insulating layer has a thickness that is greater than 2 nm and less than 20 nm.
13. The amplifier of claim 1, further comprising a substrate wherein:
the first magnetic region is on the substrate;
the control region overlies the first magnetic region; and
the second magnetic region overlies the control region.
14. The amplifier of claim 13, wherein the substrate comprises an anti-ferromagnetic material that is under the first magnetic region and that fixes the direction of the first magnetization.
15. The amplifier of claim 13, wherein the wire comprises a first segment adjacent a first side of the control region.

16. The amplifier of claim 15, wherein the wire further comprises a second segment adjacent a second side of the control region.

17. The amplifier of claim 16, wherein the first segment and the second segment are connected in series such that current in the first segment has a direction opposite to current in the second segment.

18. The amplifier of claim 13, wherein:

the control region comprises a plurality of parts, wherein each part is laterally separated from an adjacent part, and

the wire comprises a plurality of segments that reside in separations between the parts of the control region.

19. The amplifier of claim 18, wherein the segments are connected such that current in each of the segments has a direction opposite to current in an adjacent one of the segments.

20. The amplifier of claim 13, wherein the second magnetic region comprises a first part and a second part that are laterally separated from each other, the wire having a segment residing in a separation between the first and second parts of the second magnetic region.

21. The amplifier of claim 20, wherein the first part of the second magnetic region has the second magnetization and the second part of the second magnetic region has a magnetization that is antiparallel to the second magnetization.

22. The amplifier of claim 20, wherein the first part and the second part of the second magnetic region have the second magnetization.

23. A method for amplifying a signal current, comprising:

applying a first voltage difference between a first magnetic region and a second magnetic region that respectively form a first interface and a second interface with a semiconductor region that is between the first and second magnetic regions;

driving the signal current through a wire that is adjacent to the semiconductor region to create a magnetic field that rotates spins of electrons injected through the semiconductor

region between the first magnetic region and the second magnetic region; and
extracting an amplified current from a current resulting from injection between the
first magnetic region and the second magnetic region.

24. The method of claim 23, wherein the first magnetic region has a first magnetization, the second magnetic region has a second magnetization, and the first magnetization is perpendicular to the second magnetization.
25. The method of claim 23, wherein the semiconductor region is such that an electron spin relaxation time of the semiconductor region is longer than a transit time of the electrons traversing the semiconductor region.